On the rule of disorder in the conductivity of high aspect ratio carbon filled composites in the framework of complex networks

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The inclusion of high aspect ratio fillers like carbon nanotubes (CNT) or vapour grown carbon nanofibers (VGCNF) in a polymeric matrix enhances the electric and mechanical properties [1] of the matrix. The filler concentration, aspect ratio (AR) and dispersion are expected to affect the material response [1]. Both for CNT/polymer or VGCNF/polymer composites a divergence is expected in the composite conductivity for a critical volume fraction, which is usually discussed in the framework of the percolation theory [2].

In a recent review [3] the experimental percolation thresholds for CNT composites revealed the existence of a wide range of values for the same type of CNT/polymer composites, a deviation from the bounds predicted by the excluded volume theory and a dispersion for the values of the critical exponent (t) [2]. The later exponent is expected to be independent of filler geometry or matrix, taking a value that depends on the system dimension.

In this work it is demonstrated that the conductance of carbon nanotube composites can be described in the context of complex network theory, providing interesting insights into the nature of the physical phenomena behind the conductance behavior. Using the complex network framework, by mapping fillers to vertices and edges to the gap between fillers, we are able to describe the percolation threshold and relate the composite conductance with a weak disorder regime. The theoretical arguments are validated by experimental results from the literature.

References

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